IS 3525 (1998): Metal arc welding for hull constructions of merchant ships in carbon and carbon -manganese steels [MTD 12: Welding Applications]

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भारतीय मानक

व्यापारिक पोत के लिए कार्बन और कार्बन मैंगनीज इस्पात के आवरण निर्माण हेतु धातु आर्क वेल्डिंग — रीति संहिता

(दूसरा पुनरीक्षण)

Indian Standard

METAL ARC WELDING FOR HULL CONSTRUCTION OF MERCHANT SHIP IN CARBON AND CARBON MANGANESE STEELS — CODE OF PRACTICE

(Second Revision)

ICS 25.160.10; 47.02.10

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Price Group 5

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Welding Applications Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1966 and subsequently revised in 1983. In this revision additional requirements have been included in the provision regarding workmanship.

Welding is extensively adopted in the hull construction of merchant ships. With the expansion of the shipbuilding industry in India, it has become necessary to formulate an Indian Standard to unify the practices being followed in the field of metal arc welding in hull construction of merchant ships. In the formulation of this standard the requirements of the Indian shipbuilding industry have been taken into account.

This standard keeps in view the practice prevailing in the country in this field. Assistance has also been derived from the following publications:

Rules and Regulations for the Classification of Ships, 1992. The Lloyds Register of Shipping, UK.

Rules for Building and Classing Steel Vessels,1992. American Bureau of Shipping, USA.

This standard contains clauses **4**, **6**, **9.1.1** and **9.1.6** which call for agreement between the ship manufacturer and the customer or his authorized inspection agency.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METAL ARC WELDING FOR HULL CONSTRUCTION OF MERCHANT SHIP IN CARBON AND CARBON MANGANESE STEELS — CODE OF PRACTICE

(Second Revision)

1 SCOPE

This code covers the use of manual metal arc welding in the design and fabrication of merchant ships other than tankers, built in carbon and carbon manganese steels.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
812 : 1957	Glossary of terms relating to welding and cutting of metals
814 : 1991	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel (*fifth revision*)
818 : 1968	Code of practice for safety and health requirements in electric and gas welding and cutting operations (*first revision*)
822 : 1970	Code of procedure for inspection of welds
3039 : 1988	Structural steel for construction of hulls of ships (*first revision*)
3658 : 1981	Code of practice for liquid penetrant flaw detection (*first revision*)
4260 : 1986	Recommended practice for ultrasonic testing of butt welds in ferritic steel (*second revision*)
5334 : 1981	Code of practice for magnetic particle flaw detection of welds (*first revision*)
7307 (Part 1) : 1974	Approval of tests for welding procedures: Part 1 Fusion welding of steel
7310 (Part 1) : 1974	Approval tests for welder working to approved welding procedures: Part 1 Fusion welding of steel
7318 (Part 1) : 1974	Approval tests for welder when welding procedure approval is not required: Part 1 Fusion welding of steel
9595 : 1996	Metal arc welding of carbon and carbon-manganese steels — Recommendations (*first revision*)
13805 : 1993	Guidelines for certification for personnel for non-destructive testing
14419 : 1996	Acceptance standards for radiographic examination of welds for ships — Recommendations

3 TERMINOLOGY

For the purpose of this standard, definitions of arc welding terms given in IS 812 shall apply.

4 MATERIAL

4.1 Steel

Steel used for ship structural members and connections shall be of steel conforming to IS 3039 or as agreed to between the ship manufacturer and the customer or his authorized inspection agency.

4.1.1 Carbon manganese steel having UTS value 470 to 650 MPa known as higher strength steel or higher tensile steel may also be used.

4.2 Electrodes

Electrodes shall conform to IS 814 and shall be suitable for the type of material and joints to be welded.

4.2.1 Selection of electrode for welding higher tensile carbon manganese steel is done on the carbon equivalent of the material calculated from the ladle analysis.

$$\text{Carbon Equivalent} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

Where carbon equivalent is less than 0.41 percent, any type of approved higher tensile welding consumables can be used. Where carbon equivalent is in between

0.40 and 0.45 percent, approved low hydrogen (hydrogen controlled) higher tensile welding consumables are to be used, but generally preheating will not be required except under conditions of higher restraint or low ambient temperature. Where carbon equivalent is more than 0.45 percent approved low hydrogen higher tensile welding consumables and preheating are to be used.

4.2.2 For the joints between steels of different strength levels, the welding consumables may be of a type suitable for lesser grade or strength being connected. The use of a higher grade of welding consumables may be required at discontinuities or other parts of stress concentration.

4.2.3 If required, suitable preheating and post-heating are to be used.

5 PLANS AND DRAWINGS

5.1 The working drawings, charts or welding schedules shall include the following information:

a) The arrangement of the plating, disposition and type of joints together with the proposed sequence of prefabrication, assembly and welding.
b) Details of welded connections of main structural members with type and size of welds clearly indicated on the plans.
c) The structural arrangements shall be such that the amount of weld metal in a structure shall be kept to a minimum and plates of the largest practicable size employed in the interest of economy and shrinkage effect.

5.2 The structural arrangements are to be such as will admit easy access for welding operations and shall facilitate the use of down hand welding wherever possible.

5.2.1 The type and dispositions of connections and sequences of welding shall be so planned that any restraint during operations is reduced to a minimum.

6 DESIGN

Provisions regarding design of welded joints shall generally be in conformity with IS 9595.

6.1 Butt Weld

6.1.1 Butt welds should be adopted in preference to overlaps for joints in the main structure. In general, the edges of the plates to be joined by manual butt welding, the details of the edge preparation shall be in accordance with IS 9595.

6.1.2 A back sealing run shall normally be applied to all single V butt welds and to square edge butt welds where main welding is carried out from one side only except in cases where special techniques are employed and a back sealing run is not required.

6.1.3 Where a thick plate is butt welded to a thinner plate, the edge of the thick plate may be required to be tapered. The taper shall be at least 1 in 3 except that when the difference in thickness is less than 3 mm, no taper need be provided but the thicker member shall be levelled up to the top (*see* Fig. 1) edge and the weld contour shall have a uniform transition from thicker to thinner member.

6.1.4 Where stiffening member are attached by continuous fillet welds and cross completely finished butt welds or seam welds, these welds are to be made flush in any of the faying surface. Similarly, for butt welds in webs or of stiffening members, the butt welds is to be completed and generally made flush with the stiffening member before the fillet weld is made. The ends of the flush portion are to run out smoothly without notches or sudden change of section. Where these conditions cannot be complied with, a scallop (coping) is to be provided in the web of the stiffening member. Scallops shall be of such size and in such a manner that a satisfactory weld can be made.

6.2 Lap Connections

6.2.1 Generally, overlaps shall not be used to connect plates which may be subjected to high tensile or compressive loads. However, where they are adopted, the width of overlap is to be adequate to ensure a good weld and the surfaces are to be in close contact.

6.2.2 The use of permanent backing material in highly stressed zones should be avoided, where use of backing material is unavoidable, special care shall be taken to ensure accurate fit-up.

6.2.3 For the connection of plating to internal webs, where access for welding is not practicable, the closing plating is to be attached by continuous full penetration or slot welds to flat bars fitted to the webs. Slot shall have a minimum length of 75 mm and in general a minimum width of twice the plating thickness with well rounded ends. The distance between slots shall

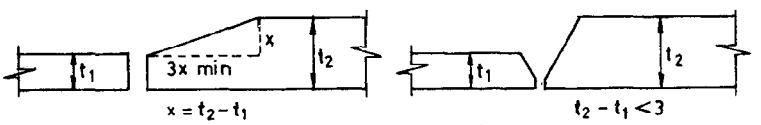


FIG. 1 BUTT WELDING OF PARTS OF UNEQUAL THICKNESS

not exceed 150 mm. Normally, slots shall not be filled by welding.

6.3 Fillet Welds

6.3.1 t-connections shall generally be made by fillet welds on both sides of the butting plate. When the connection is highly stressed, deep penetration or full penetration welds may be required. When full penetration welding is required, the abutting plate may be required to be bevelled.

6.3.2 The throat thickness of the intermittent fillet welds shall be obtained from the following formula (*see also* Fig. 2):

$$\text{Throat thickness} = t \times \text{Weld factor} \times \frac{d}{s}$$

where

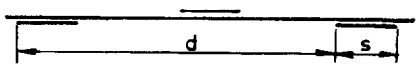
s = the length in mm of correctly proportioned fillet weld clear of end craters and shall be not less than 75 mm;

d = distance in mm between successive fillet welds; and

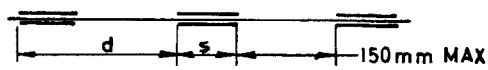
t = plate thickness in mm on which the weld size is based.

Weld factors given in Table 1 are for general guidance only. Weld factors other than those given in Table 1 may be followed subject to agreement between the ship manufacturer and the customer or his authorized inspection agency.

Staggered intermittent to be doubled at ends



Chain intermittent



Scalloped frames, longitudinals stiffeners, etc, with double fillet welds. Welding to be carried round the ends of all lugs

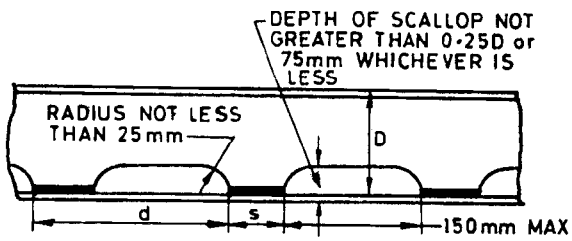


FIG. 2 DETAILS OF SCALLOPED CONSTRUCTION

Table 1 Weld Factors for Various Structural Connections

(*Clauses* 6.3.2 *and* 6.3.3)

Sl No.	Item	Weld Factor	Remarks
(1)	(2)	(3)	(4)
i)	General applications:		
	Watertight or oiltight plate boundaries	0.34	Except as required below
	Non-tight plate boundaries	0.13	
	Longitudinals, frames, beams and	0.10	
	other secondary members to shell,	0.13	In tanks
	deck or bulkhead plating	0.21	In way of end connections
	Panel stiffness, etc	0.10	
	Overlap welds generally	0.27	
	Longitudinals of flat bar type of plating		*See* Note 1
ii)	Bottom construction in way of holds:		
	Non-tight centre girder:		
	To keel	0.27	
	To inner bottom	0.21	No scallops
	Non-tight boundaries of floors, girders and brackets	0.21	In way of 0.2 × span at ends
		0.27	In way of brackets at lower end of main frame
	Inner bottom longitudinals or reverse frames	0.13	Under holds strengthened for heavy cargoes
iii)	Hull framing:		
	Welds of web frames and stringers:		
	To shell	0.16	

Table 1 (*Continued*)

Sl No. (1)	Item (2)	Weld Factor (3)	Remarks (4)
	To face plate	0.13	
	Tank side brackets to shell and inner bottom	0.34	
iv)	Decks and supporting structure:		
	Strength deck plating to shell		
	$t \leq 15$	0.44	Double continuous fillet weld
	$15 < t \leq 20$	0.39	Single V preparation to provide included angle of 50° with root $\leq \frac{1}{3}t$ in conjunction with a continuous fillet weld. Double V preparation to provide included angle of 50° with root $\leq \frac{1}{3}t$
	$t > 20$	Full penetration	Double V preparation to provide included angle of 50° with root $\leq \frac{1}{3}t$ but not to exceed 10 mm
	Other decks to shell and bulkheads (except where forming tank boundaries)	0.21	Generally continuous
	Webs of cantilevers to deck and to shell in way of root brackets	0.44	
	Webs of cantilevers to face plate	0.21	
	Pillars:		
	Fabricated	0.10	
	End connections	0.34	*See* Note 2
	End connections (tubular)	Full penetration	
	Girder web connections and brackets in way of pillar heads and heels	0.21	Continuous
v)	Bulkheads and tank construction:		
	Bulkhead boundary at bottom	0.39	
	Bulkhead boundary at inner bottom bilge	0.44	
	Secondary members where acting as pillars	0.13	
	Perforated flats and wash bulkhead boundaries	0.10	
	Connections of swedged bulkhead to plating	0.44	
	Non-watertight bulkhead boundaries	0.13	
vi)	Structure in machinery space:		
	Centre girder to keel and inner to inner bottom	0.27	No scallops to inner bottom
	Floors to centre girder in way of engine, thrust and boiler bearers	0.27	
	Floors and girders to shell and inner bottom	0.21	
	Main engine foundation girders:		
	To top plate	Full penetration	Full penetration generally
	To hull structure	To depend on design	
	Floors to main engine foundation girders	0.27	
	Brackets, etc, to main engine foundation girders	0.21	
	Transverse and longitudinal framing to shell	0.13	
vii)	Construction in 0.25 L forward:		
	Floors and girders to shell and inner bottom	0.21	
	Bottom longitudinals to shell	0.13	
	Transverse and longitudinal side framing to shell	0.13	
	Tank side brackets to frame and inner bottom	0.34	
	Panting stringers to shell and frames	0.34	
	Fore peak construction: All internal structure	0.13	Unless a greater weld factor is required
viii)	After peak construction:		
	All internal structures and stiffeners on after peak bulkhead	0.21	Unless a greater weld factor is required
ix)	Superstructures and deckhouses:		
	Connection of external bulkheads to deck	0.34	First and second tier erection
		0.21	Elsewhere
	Internal bulkheads	0.13	
x)	Hatchways and closing arrangements:		
	Hatch coaming to deck	0.34	0.44 at corners

Table 1 (*Concluded*)

Sl No.	Item	Weld Factor	Remarks
(1)	(2)	(3)	(4)
	Hatch cover rest bar	0.16	
	Hatch coaming stays to coaming	0.13	
	Hatch coaming stays to deck	0.21	
	Cleats and fittings	0.44	Full penetration welding may be required
	Primary and secondary stiffening to hatch covers	0.10	0.13 for tank covers and where covers strengthened for load cover
xi)	Steering control system:		
	Rudder: Fabricated main piece and main piece to side plates and webs	0.44	
	Slot welds in side plates	0.44	
	Remaining construction	0.21	
	Fixed and steering nozzles:		
	Main structure	0.44	
	Elsewhere	0.21	
	Fabricated housing and structure of thruster units, stabilizers, etc:		
	Main structure	0.44	
	Elsewhere	0.21	
xii)	Miscellaneous fittings and equipment:		
	Rings for manhole type covers to deck or bulkhead	0.34	
	Frames of shell and weathertight bulkhead doors	0.34	
	Stiffening of doors	0.21	
	Ventilators, air pipe, etc, coamings to deck	0.34	Load line position 1 and 2
		0.21	Elsewhere
	Scuppers and discharges, to deck	0.44	
	Ventilators, etc, fittings	0.21	
	Masts, derrick posts, crane pedestals, etc, to deck	0.44	Full penetration welding may be required
	Deck machinery seats to deck	0.21	Generally
	Mooring equipment seats	0.21	Generally, but increased or full penetration welding may be required
	Bulwark stays to deck	0.21	
	Bulwark attachment, to deck	0.34	
	Guard rails, stanchions, etc, to deck	0.34	
	Bilge keel to ground bars	0.21	
	Fabricated anchors	Full penetration	

NOTES

1 Where the thickness of the abutting member of the connection (for example, the web of a stiffener) exceeds the thickness of the table member (for example plating), the welding is to be double continuous and the throat thickness of the weld is not to be less than the greatest of the following: (a) 0.21 × thickness of the table member, (b) 0.21 (0.27 in tanks) × half the thickness of the abutting member, and (c) as required by item (iii) in Table 2.

2 Where the pillars are fitted inside tanks or under watertight flats, the ends connection is to be such that the tensile stress in the weld does not exceed 108 MPa.

3 This table does not include special structural requirements for cargo oil tanks in tankers, cargo chemical tankers and hopper and hopper dredgers, etc.

6.3.3 Where an approved automatic deep penetration procedure is used, the weld factors given in Table 1 may be reduced by 15 percent.

6.3.4 Where double continuous fillet welds are used, the throat thicknesses shall be determined taking $d = S$.

6.3.5 The leg length of the weld shall not be less than $\sqrt{2}$ multiplied by specified throat thickness and for specified leg size, the throat thickness shall not be less than 0.7 leg length of the weld.

6.3.6 The plate thickness t, to be used in the formula given in **5.3.2**, shall generally be that of the thickness of the thinner of the two part being welded. Where the difference in thickness is considerable the size of the fillet weld needs a consideration.

6.3.7 Where the thickness of the abutting member of the connection (for example, the web of a stiffener) exceeds the thickness of the plate (abutted member), the welding is to be double continuous, and the throat thickness of the weld is to be not less than the greatest of the following:

a) 0.21 × thickness of the table member (member abutted),
b) 0.21 × half the thickness of the abutting member, and
c) as required under item (iii) of Table 2.

Table 2 Limits of Throat Thickness
(*Table* 1 and *Clauses* 6.3.7, 6.3.8, 6.4.3, 6.5.2 *and* 6.5.6)

Sl No.	Weld Details	Throat Thickness	
		Minimum mm	Maximum mm
(1)	(2)	(3)	(4)
i)	Double continuous welding	0.21 t	0.44 t
ii)	Intermittent welding	0.27 t	0.44 t or 4.5
iii)	All welds, overriding minimum:		
	a) Plate thickness $t \leq 7.5$ mm Hand or automatic welding	3.0	—
	Automatic deep penetration welding	3.0	—
	b) Plate thickness $t > 7.5$ mm Hand or automatic welding	3.25	—
	Automatic deep penetration welding	3.0	—

6.3.8 Except as permitted under **6.3.7** the throat thickness of the weld shall be within limits specified in Table 2.

6.3.9 Continuous welding shall be used in the following location:

a) Boundaries of weathertight decks and erections, including hatch coamings, companionway and other openings;
b) Boundaries of tanks and watertight compartments;
c) All structure in the peak and after peak bulkhead stiffeners;
d) All lap welding in inside tanks intended for chemical or edible liquid cargoes;
e) All lap welds in tanks;
f) Primary and secondary members to bottom shell in the 0.3 L forward;
g) Primary and secondary members to plating by way of end connections, and end brackets to plating in the case of lap connections;
h) Fillet weld when higher tensile steel is used;
j) Where **6.3.7** applies; and
k) Other connections or attachments where considered necessary and in particular the attachment of minor fittings to plate of higher tensile strength steel.

Continuous welding may also be used in other location, if desired.

6.3.10 Where intermittent welds are used, welding shall be made continuous round the ends of brackets, lugs, scallops at the end of all structural members and at the orthogonal connections with other members. In general craters at the end of each weld should be properly filled up.

6.3.11 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetrations welding is to be adopted for members for at least 150 mm on each side of the boundary. Alternatively a small coping or scallop of suitable shape may be cut in the member close to the boundary outside the compartment and carefully welded all round.

6.4 Welding of Primary Structure

6.4.1 The weld connection to shell, deck or bulkhead is to take account of the material lost in the notch where longitudinal or stiffeners pass through the member. Where the width of notch exceeds 15 percent of the stiffener spacing, the weld factor shall be multiplied by:

$$\frac{0.85 \times \text{Stiffener spacing}}{\text{Length of web plating between notches}}$$

6.4.2 Where direct calculation procedures have been adopted the weld factors for the '0.2 × overall length at the ends of members' shall be considered in relation to the actual loads.

6.4.3 The throat thickness shall conform to the requirements of Table 2.

6.5 Welding of Primary and Secondary Member and Connections

6.5.1 Welding of end connections of primary members shall be such that the weld area is not less than the cross-sectional area of the member, and the weld factor is not less that 0.34 on tank or 0.27 elsewhere.

6.5.2 In the case of secondary member end connections, the weld area and weld factor shall not be less than the values specified in Table 3. The maximum and minimum sizes of fillet are specified in Table 2.

6.5.3 The area of weld, A_W shall be applied to each arm of the bracket or lapped connection.

6.5.4 Where a longitudinal strength member is cut at a primary support and the continuity of strength is provided by brackets, the area of weld is to be not less than the cross-sectional area of the member.

6.5.5 Where a longitudinal strength member passes through, and is supported by the web of a primary (member, the weld connection) connection shall have an area not less than 0.5 $\sqrt{Z}$ and weld factor of $0.27\sqrt{Z}$ shall be defined in Table 3.

6.5.6 The limits of throat thickness specified in Table 2 shall be complied with keeping in view the requirements of IS 9595.

Table 3 Primary and Secondary Member End Connection Welds
(*Clauses* 6.5.2 *and* 6.5.5)

Sl No.	Connections	Weld Area, A_w cm^2	Weld Factor
(1)	(2)	(3)	(4)
i)	Stiffener welded direct to plating	0.25 A_s or 6.5 cm^2 whichever is greater	0.34
ii)	Bracketless connection of stiffeners or stiffener lapped to bracket or bracket lapped or stiffener:		
	a) In dry space	1.2 $\sqrt{Z}$	0.27
	b) In tank	1.4 $\sqrt{Z}$	0.34
	c) Main frame to tank side bracket in 0.15 L forward	as (a) or (b)	0.34
iii)	Bracket welded to face of stiffeners and bracket connection to plating	—	0.34
iv)	Stiffener to plating for 0.1 × space at ends, or in way of end bracket if that be greater	—	0.34

NOTES

1 A_s = cross-sectional area of stiffener in cm^2.

2 A_w = area of weld in cm^2 calculated as total length × throat thickness.

3 Z = sections modulus in cm^3, of the stiffener on which the scantlings of the bracket are based.

7 WORKMANSHIP

7.1 The workmanship shall take into consideration all the design aspects given in **6**. Welders and operators of welding equipment shall be qualified in the type of work in which they are engaged. A sufficient number of skilled supervisors shall be provided to ensure effective control at all stages of assembly and welding operators. The welding plant and appliances shall be suitable for the purpose intended and shall be maintained in an efficient condition.

7.2 The welding procedures for all joints shall be established for the type of electrodes, edge preparation, welding position, etc, in accordance with IS 7307 (Part 1).

7.3 The preparation of plate edges shall be accurate and uniform. All joints shall be properly aligned and closed or adjusted before welding. Excessive force shall not be used in finishing the work. Means should be provided for holding the work in proper alignment without rigid restraint during welding operations, and should allow for expansion and contraction during production welding.

7.4 Tack welding should be kept to a minimum and where used the tack weld should be equal in quality to the finished welds. All defective tack welds should be cut out before completing the finished welds.

7.4.1 Care shall be taken when removing tack welds and temporary fittings used for assembly to ensure that the material of the full is not damaged. Minor weld deposits on a plate will reduce its capacity to withstand explosive loading they may initiate major brittle fractures even after the weld deposit has been grounded off. The number of such deposits, made for the attachment of temporary connections shall therefore be reduced. Stray flashes caused by arcing from the electrode or electrode holder or from an inefficient earth connection have a similar effect and shall be carefully guarded against.

7.5 The surface of all parts to be welded shall be clean, dry and free from rust, scale and grease. The surfaces and boundaries of each run of deposit shall be thoroughly cleaned and freed from slag before the next run is applied. Approved primer coatings of minimum thickness may be used.

7.5.1 No welding shall be performed upon the shell plating below the water line of a ship which is afloat, except as a temporary measure in case of emergency.

7.5.2 Before a sealing run is applied to the back of a weld, where required the original root run shall be gouged to sound metal. Where arc-air gouging is done, ensure removal of slag and carbon particles from the groove by grinding/chipping and wire brushing before commencement of welding.

7.5.3 Welding shall proceed systematically, each welded joint being completed in proper sequence without undue interruption.

7.5.3.1 Where it is not possible to weld the butt or seam first before the crossing stiffening member is watertight, an opening of suitable size with well rounded corners and not less than 100 mm diameter may be cut in the stiffening or abutting member and can later be blanked with a watertight collar with rounded edges welded both sides and with a minimum lap of 40 mm after finishing the butt or seam.

7.5.4 Adequate protection shall be provided where welding is required to be carried out in exposed conditions in wet, windy or cold weather. In cold weather, precautions should be taken to screen and pre-warm the work to prevent too rapid cooling of the weld; special care is necessary when welding thick material.

7.6 All finished welds shall be sound, uniform and substantially free from slag inclusions, porosity under-cutting or other defects. Care shall be taken to ensure thorough penetration and fusion.

7.7 When the structure embodies both welding and riveting, welded joints shall in general be completed before riveting in their vicinity.

8 WELDING SEQUENCE

It is not possible to avoid contraction due to welding and due allowance shall, therefore, be made when welding is to be carried out. In the sequence of

welding, the various joints should be so placed that the contractions do not produce harmful effects. In order to allow freedom of movements to parts being joined, the following may be noted (*see also* IS 9595):

a) Contraction across welded joints is generally more troublesome than along their length;
b) Accumulated contractions due to welding of stiffening members to the plating may be considerable;
c) Welding should commence from a central area and progress symmetrically outwards so that shrinkage on both sides of the structure will be equal. Welding shall always be towards freedom and never towards fixity if this is possible;
d) No weld should be carried across over the welded joints, except as otherwise permitted in the standard; and
e) Where the transverse joint meets a longitudinal joint, the welding of longitudinal joint may be discontinued well clear of the junction and continued only after the transverse joint is completed. The welding of the transverse joint should be continued past the open longitudinal joint and the weld in way of the longitudinal joint may be chipped off later for the longitudinal joint to be completed.

9 INSPECTION

9.1 Effective arrangements shall be provided for the inspection of welding operations to ensure that all welding has been carried out satisfactorily (*see also* IS 822).

9.1.1 Visual inspection for examination of important structural welds may require to be supplemented by other forms of non-destructive testing methods, such as:

a) Ultrasonic flaw detection (*see* IS 4260),
b) Liquid penetrant flaw detection (*see* IS 3658), and
c) Magnetic particle flaw detection (*see* IS 5334), etc.

A system of radiographic examination shall be agreed between the ship builder and the customer or his authorized inspection agency and where this is done the inspector shall collaborate with the ship builders in the system of inspection. However, **9.1.2** to **9.1.4** give some guidance regarding carrying out radiographic examination of welded joint.

9.1.2 Random tests by means of radiographic examinations of butt welded joints should be carried out by the shipyard in accordance with Table 4.

9.1.3 In addition, radiographic examinations should be carried out of parts subject to heavy structural stresses, for example, deck girders, cantilevers, masts and posts for cargo gear. The exact position of individual welds to be tested shall be indicated by the inspecting authority, after the welded joints have been completed. Records of all radiographic examinations (first and repeated radiographs) shall be maintained and submitted when called for by the inspecting authority.

9.1.4 Particular attention should be paid to the following locations:

a) Junctions and crossings of seams and butts in strength deck, sheer strake, side and bottom shell within 0.4 L amidship;
b) Butts of keel plating and rounded sheer strake within 0.4 L amidships;
c) Insert plates in way of hatch opening in the strength deck; and
d) In the midship region, at the butts of blocks welded in dock or slipway.

9.1.5 Where tendency for delayed cracking is expected, consideration is to be given to delaying the final non-destructive testing to accommodate occurrence and detection of such defects.

Table 4 Radiographic Examination of Joints
(*Clause* 9.1.2)

Sl No.	Position of Parts to be Examined	Number of Radiographs of Longitudinal/ Transverse Joints for Length of Ship, L, m					
		≤ 50	≤ 80	≤ 120	≤ 160	≤ 200	> 200
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Strength deck of shear strake	2/4	4/8	6/12	8/18	10/24	12/30
ii)	Bottom plating including bilge strake	2/4	4/8	6/12	8/18	10/24	12/30
iii)	Hatch corners within the midship region	2	2	4	6	8	10
iv)	Hatchway coamings, girders of strength deck per hatchway	2	4	4	4	4	6
v)	Hatchway coamings of second deck per hatchway	2	2	3	3	3	4
vi)	Stern frame	2	2	2	3	4	5
vii)	Other places	4	6	8	12	16	22

9.1.6 Acceptance criteria of radiographic examination shall be in conformance to IS 14419 or as agreed between the ship builder and the customer or his authorized inspection agency.

9.1.7 Examination of weld joints by ultrasonic flaw detection method (*see* IS 4260) can be done *in lieu* of radiographic examination if agreed between shipbuilder and the customer or his authorized inspection agency.

10 REPAIR OF DEFECTIVE WELDS

10.1 Defective welds shall be removed by the use of mechanical cutting tools, by grinding, chipping, flame or arc gouging.

10.2 Care shall be taken that cutting out extends to a sufficient depth to remove the defect and results in a shape which will permit satisfactory rewelding.

10.3 As rewelding a cut out portion of a welded butt joint has to be performed under conditions of severe restraint, it would be advisable to preheat the area to be repaired to 100°C and carry out rewelding manually.

10.4 Where the whole of the welding in a butt joint in a completed structure has to be removed, the seams at each end of the butt shall be cleared for a distance of 300 mm on either side of the butt. The existing butt on either side will be tapered by pneumatic chipping to prevent occurrence of defects at the junction. The butt shall be completely rewelded before the seams are completed. Preheating to 100°C is advisable throughout the whole welding operation.

10.5 Repairs which have been carried out as a result of radiographic examinations at those positions shall be re-radiographed on completion of the repair.

10.6 Special precautions, such as the use of both preheat and low hydrogen electrodes, are to be considered when repairing welds in higher strength steel, materials of thick cross section or materials subject to high restraint.

11 OPERATOR QUALIFICATION

Welding operators shall be qualified in accordance with IS 7310 (Part 1) or 7318 (Part 1) and NDT personnel shall be qualified in accordance with IS 13805.

12 SAFETY REQUIREMENTS AND HEALTH PROVISIONS

For purpose of safety requirements and health provisions, reference should be made to IS 818. Special precautions needed in this respect are given in Annex A.

ANNEX A

(*Clause* 12)

SAFETY PRECAUTIONS FOR ELECTRIC ARC WELDING

A-1 DANGER OF ELECTRICAL SHOCK

The welding plant including the cable should be in accordance with appropriate Indian Standard. The cables and connections should be sound and of adequate size. Earthing arrangements on the input side as well as for the work piece should be properly made. Normally voltages in excess of 100 volts are not required which is safe for normal condition, however, it is preferable to exercise special care with equipment when the welder has to work in either cramped spaces or damp conditions. For cases using a.c. supply it is recommended that a low voltage device is installed so that on the arc being extinguished the voltage at the holder drops to about 40 volts.

A-2 ARC RADIATION

In the process of welding, ultra-violet, infra-red and visible light and heat are radiated from the arc. Ultra-violet radiation can cause intense irritation of the eye and a sun-burned face. Infra-red radiation causes exposed parts of the body to be uncomfortably hot and damage to the eyes may occur in time. Excessive visible light causes eye strain and headaches. Appropriately graded filter glasses may be used. Neighbouring workers may be protected by use of fireproof portable welding screens.

A-3 SPATTER AND DESLAGGING

Shields and protective clothing like gloves, aprons, helmets, etc, shall be worn to protect body from heat and to prevent burns from spatter slag. When seams are being deslagged, clear glasses or other visual protection shall be worn.

A-4 FUMES

When working in confined spaces, fumes given off when welding is carried out can be very objectionable. Proper ventilation is, therefore, essential.

A-5 EXPLOSION AND FIRES

Unless suitable measures have been taken explosion may occur when welding is carried out in the vicinity of oil storage spaces. Best prevention would be to gas free oil storage space before welding is proceeded with. Combustible material should be removed from the region of welding to prevent fire. Fire extinguishers should be readily available.

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